

## Research Highlight

The quantification of aerosol optical properties is critical for understanding the role of aerosols in atmospheric visibility and in the atmosphere's radiative energy balance. Aerosols' perturbation of the atmosphere's radiative balance may result in warming or cooling of the Earth's atmosphere. This is, in part, dependent on the balance between absorption and scattering of light by aerosols. Relative humidity (RH) plays an important role in the direct radiative forcing of aerosols because elevated RH conditions can cause aerosol particles to uptake water, altering their size and composition and thus their interaction with light. Instrumental challenges have repeatedly hampered the characterization of light absorption by aerosol under elevated RH conditions. It is particularly challenging to quantify the absorption of weakly absorbing material such as primary organic carbon (OC) aerosol that is generated by biomass combustion, which accounts for up to 70% of primary OC aerosol in the atmosphere.

A short path extinction cell and a nephelometer were improved and then used to measure in situ light extinction and light scattering, respectively, at visible wavelengths of light to then determine light absorption by difference at controlled RH conditions. This research was conducted with laboratory-generated aerosol, allowing carefully controlled and reproducible conditions.

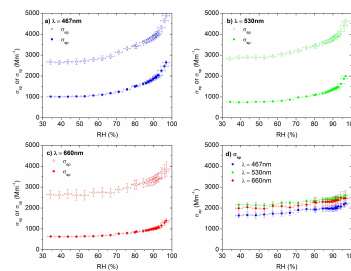
Benchmarking with humidified ammonium sulfate aerosol indicated that the optical measurements matched modeled values within uncertainties. Additional benchmark tests measured single-scattering albedo of absorbing polystyrene microspheres within 0.02 of previously reported results. The light absorption by nigrosin (Figure 1d) showed a similar wavelength dependence as previously reported for bulk measurements of aqueous solutions. The absorption increased by a factor of 1.24 +/- 0.06 at 95% RH compared to dry conditions at all measured wavelengths.

Oak wood was then pyrolyzed at 425°C to generate primary OC aerosol similar to that found in the atmosphere. Previously reported spectral dependencies of light absorption by OC as determined with filter and bulk liquid measurements were confirmed in situ. Extinction and scattering by this aerosol both increase after about 70% RH (Figures 2a and 2b). Light absorption for this aerosol increased by a factor of 2.2 +/- 0.7 and 2.7 +/- 1.2 as RH increased to 95% at wavelengths of 467 nm and 530 nm, respectively (Figures 2c and 2d). At 660 nm wavelength, OC light absorption is very low so that the hygroscopic absorption growth factor at that wavelength is noisy (Figure 2d).

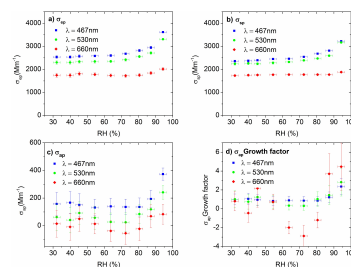
It is important to understand the effect of RH on light absorption by OC aerosol emitted from biomass combustion. Such information can be used to better describe how this material, a large fraction of primary OC aerosol emitted globally, affects radiative transfer through the earth's atmosphere, and thus climate change. Current global climate models do not account for RH dependencies in light absorption by OC. These results present, for the first time, measured values for in situ optical properties including absorption at RH values up to 95%. The use of tightly controlled conditions allows us to attribute changes in optical properties to OC emitted from biomass pyrolysis and combustion.

## Reference(s)

Brem BT, FC Mena Gonzalez, SR Meyers, TC Bond, and MJ Rood. 2011. "Laboratory-measured optical properties of inorganic and organic aerosols at relative humidities up to 95%." *Aerosol Science and Technology*, 46(2), doi:10.1080/02786826.2011.617794.



Optical properties of the nigrosin benchmark aerosol as a function of relative humidity (RH). Measured extinction ( $\sigma_{ep}$ ) and scattering ( $\sigma_{sp}$ ) for 467 nm, 530 nm and 660 nm are shown in 1a), 1b) and 1c); calculated absorption ( $\sigma_{ap}$ ) is shown in 1d). Measurement errors in optical properties and RH values are described by vertical and horizontal bars, respectively.



Optical properties at controlled RH conditions for primary OC aerosol generated by pyrolysis of oak biomass. Extinction ( $\sigma_{ep}$ ), scattering ( $\sigma_{sp}$ ), and absorption ( $\sigma_{ap}$ ) for three wavelengths are shown in 2a), 2b), and 2c), respectively; the hygroscopic growth factor for light absorption is shown in 2d). Measurement errors in optical properties and RH values are described by vertical and horizontal bars, respectively.

## Contributors

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## Working Group(s)

Aerosol Life Cycle